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HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
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COAL-MINE EXPLOSIONS AND COAL- AND METAL-MINES FIRES IN THE UNITED STATES DURING THE FISCAL YEAR ENDED JUNE 30, 1940

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BY

D. HARRINGTON AND W. J. FENE

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

COAL-MINE EXPLOSIONS AND COAL- AND METAL-MINE FIRES IN THE UNITED STATES DURING THE FISCAL YEAR ENDED JUNE 30, 1940[1]

By D. Harrington[2] and W. J. Fene[3]

INTRODUCTION

Approximately 6,000 coal mines are operated in the United States. All of them have in some degree the elements that are likely to contribute to an explosion, hence it is surprising that explosion disasters are not more frequent and that many mines have been operated for years and finally worked out and abandoned without experiencing an explosion. The absence of coal-mine explosions does not always indicate that effective efforts have been made to prevent them but rather that the mine has been fortunate in that the combination of circumstances necessary to cause an explosion has not existed.

In view of present knowledge of the methods of preventing explosions, disasters are inexcusable and discredit the mining industry. The methods of preventing mine explosions are known to experienced, well-informed persons engaged in coal mining, yet despite this knowledge far to many coal-mine operators continue to use practices and methods that they should know have resulted in numerous explosions. Moreover, many mine workers persist in following past procedure irrespective of consequences and in breaking safety rules or indulging in practices almost certain eventually to result in disaster. Continued failure to apply known common-sense methods of accident and explosion prevention unquestionably will call for ultimate enforcement of law.

Coal-mining men deserved to rejoice over the splendid explosion record for the fiscal year ended June 30, 1939, which was the first consecutive 12-month period in the present century without a major disaster in the coal mines of the United States, but gloom prevails when the record for the fiscal year 1940 is considered. During the past fiscal year 18 explosions, of which 3 were major disasters, resulted in 206 deaths compared to 14 minor explosions and 16 deaths in 1939. The high fatality rate for explosions in 1940 resulted chiefly from the three major explosions with their 191 deaths.

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7136"

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Pennsylvania, the largest coal-producing State in the United States, is an excellent example of what may be done in preventing explosions; this State had a rather poor explosion record during the decade before 1930 but by adopting numerous explosion-prevention measures now has greatly curtailed the occurrence of widespread explosions. Pennsylvania has approximately 1,300 bituminous-coal mines with an annual production of 75 to 100 million tons of coal, which now have the enviable record of having had only three major explosions and 26 deaths during the past 10 years with no deaths from explosions during the past fiscal year; however, a major explosion causing 63 deaths occurred just after the end of the fiscal year. Pennsylvania anthracite mines also have a creditable record as to explosion disasters in the last 10 years, having had only 4 major explosions with a total loss of life of 33; moreover at the time this paper was written they had the excellent record of not having suffered a major disaster in more than 2 years.

SUMMARY OF MINE EXPLOSIONS BY STATES AND CAUSES

Table 1 summarizes essential data on 18 explosions, known to have occurred in 12 States, which resulted in 206 deaths during the fiscal year ended June 30, 1940. This table includes information on all coal-mine explosions in the United States during the fiscal year brought to the attention of the Bureau of Mines and is believed to cover every explosion in which life was lost or considerable damage resulted. The 18 explosions that occurred during the year were 4 more than the number known to have occurred during the previous year, and the number of deaths (206) was 190 more than occurred during the fiscal year ended June 30, 1939, when only 16 fatalities were chargeable to coal-mine explosions.

The greatest number of deaths from explosions (95) during the past fiscal year occurred in West Virginia; Ohio had 72, Kentucky 28, Arkansas 3, Oklahoma 2, and Alabama, Colorado, Illinois, Tennessee, Virginia, and Washington 1 each. Alabama had four explosions; Pennsylvania, Washington, and West Virginia had two each; and Arkansas, Colorado, Illinois, Kentucky, Ohio, Oklahoma, Tennessee, and Virginia had one each.

The three major explosions during the year resulted in 191 deaths; during 1939 there were no major explosions, and during 1938 there were eight major explosions with 146 deaths. Five of the 18 explosions known to have occurred during the year did not result in fatalities. The anthracite mines of Pennsylvania, employing approximately 100,000 men and producing 40 to 50 million tons of coal from mines, many of which are extremely gassy, have the very good record of operating more than 2 years without a single major explosion.

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TABLE 1. - Summary of coal-mine explosions, by States and causes, fiscal year ended June 30, 1940 1/

State	Lighting used			Fatalities by ignition causes									
	Open	Closed	Unknown	Electricity		Open lights or smoking		Explosives		Miscellaneous or unknown		Total	
				Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions
Alabama.....	1	3	-	-	1	1	2	-	1	-	-	1	4
Arkansas.....	1	-	-	-	-	-	-	3	1	-	-	3	1
Colorado.....	-	-	1	1	1	-	-	-	-	-	-	1	1
Illinois.....	-	1	-	1	1	-	-	-	-	-	-	1	1
Kentucky.....	-	1	-	-	-	-	-	28	1	-	-	28	1
Ohio.....	-	1	-	-	-	-	-	72	1	-	-	72	1
Oklahoma.....	1	-	-	2	1	-	-	-	-	-	-	2	1
Pennsylvania.....	2	-	-	-	-	-	2	-	-	-	-	0	2
Tennessee.....	1	-	-	-	-	-	-	-	-	1	1	1	1
Virginia.....	-	1	-	-	-	1	1	-	-	-	-	1	1
Washington.....	-	2	-	-	-	-	-	-	1	1	1	1	2
West Virginia....	-	2	-	95	2	-	-	-	-	-	-	95	2
Total.....	6	11	1	99	6	2	5	103	5	2	2	206	18

1/ Includes data on all coal-mine explosions in the United States insofar as could be ascertained by the Safety Division of the Bureau of Mines.

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Table 2 summarizes the causes of explosions that occurred during the fiscal years 1929 to 1940, as determined from records of the Safety Division of the Bureau of Mines. It shows that 99 persons were killed during the past fiscal year in explosions initiated by electricity compared with 13 the previous year and an average of 54.2 per year for the preceding 11 years. Deaths from explosions due to electricity increased almost sevenfold compared with the previous year and more than 82 percent compared with the average of the previous 11 years. There were six explosions of electrical origin during the fiscal year 1940 compared with nine such explosions during the previous fiscal year and an average of 10.8 during the previous 11 fiscal years. West Virginia had two explosions caused by electricity with 95 deaths; Oklahoma, one with 2 deaths; Colorado and Illinois, one with 1 death each; and Alabama, one with no deaths.

During the fiscal year 1940 five explosions were caused by open lights and smoking compared with three during the previous year and an average of 9.7 during the preceding 11 years. Only two deaths resulted from explosions caused by open lights and smoking in 1940 compared with two deaths from this cause the previous year and an average of 26.1 deaths for the preceding 11 years. Explosions caused by open lights and smoking occurred in Alabama, Pennsylvania, and Virginia. In two of these explosions gas was ignited by carbide lamps; in two others, in closed-light mines, one miner was killed and another injured when they ignited gas with a match in attempting to smoke; and in still another, in a small wagon mine, a man and a boy were burned when gas was ignited by a match in an attempt to relight a lantern.

Five explosions resulting in 103 deaths are known or suspected to have been caused by explosives during the past fiscal year compared with no explosions from this cause during the previous year and an average of 3.8 explosions and 19 deaths during the preceding 11 years. One of these explosions, in a Kentucky mine, resulted in the death of 28 men and was caused by the ignition of coal dust by the accidental explosion, in the open, of a primer and possibly additional sticks of permissible explosives. In another explosion, in an Ohio mine, 72 men were killed as a result of an overcharged shot of black blasting powder which is thought to have ignited dust and possibly gas. Both of these disasters occurred in highly mechanized mines with the working shift in the mine.

In these two major explosions some of the dangers and inconveniences of using haulage roads for return airways were clearly demonstrated. In one disaster 3 men were killed and 23 overcome by poisonous gases on the main haulage road, and recovery work was delayed many hours until the ventilation could be reversed; in the other, 9 men who made an effort to barricade themselves and who lived at least 6 hours following the explosion could have been reached and rescued or possibly could have walked out if the haulage roads had been on intake air. Some State laws require haulage roads to be on intake air, while others fail to provide adequately for this important safety measure.

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TABLE 2. - Summary of data on explosions, by causes, fiscal years 1929-40[1/]

Year	Lighting used			Fatalities by ignition causes									
	Open	Closed	Unknown	Electricity		Open lights or smoking		Miscellaneous Explosives		or unknown		Total	
				Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions
1929.....	18	19	1	93	18	14	11	26	8	6	1	139	38
1930.....	8	25	1	154	18	21	8	24	6	-	2	199	34
1931.....	12	14	-	143	9	56	11	18	6	-	-	217	26
1932.....	15	14	4	11	10	33	15	42	5	1	3	87	33
1933.....	7	14	1	25	8	63	8	29	4	5	2	122	22
1934.....	9	14	3	21	10	2	9	2	3	3	4	28	26
1935.....	6	17	-	29	10	6	9	3	2	16	2	54	23
1936.....	15	9	1	20	5	10	17	4	1	4	2	38	25
1937.....	4	12	4	53	12	3	5	-	1	6	2	62	20
1938.....	10	16	3	24	10	77	11	61	6	8	2	170	29
1939.....	2	12	-	13	9	2	3	-	-	1	2	16	14
1940.....	6	11	1	99	6	2	5	103	5	2	2	206	18
Total.....	112	177	19	685	125	289	112	312	47	52	24	1,338	308

1/ The fiscal year ends June 30.

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Two explosions from miscellaneous or unknown causes resulted in two deaths. One of them is reported to have occurred when gas was ignited by the flame of an unassembled flame safety lamp or when an attempt was made to relight the unassembled lamp with the igniter in the presence of gas; one man was killed, and two were injured by burns. This explosion occurred in a closed-light mine where gas was known to be liberated and where coal is shot off the solid with permissible explosives, using fuse and detonators, the fuse being lighted with "punk." In the other explosion one man was killed and two were injured by burns when gasoline vapor from a leaking line on a gasoline locomotive was ignited by a carbide lamp, the locomotive magneto, or the exhaust.

In underground coal mines in which the management permits the use of gasoline locomotives and flame safety lamps that can be disassembled at the will of the worker while in the mine, disasters may be expected; both of these practices are extremely dangerous.

RECORD OF EXPLOSIONS, BY STATES

Table 3 shows the record of explosions, by States, for the past 12 fiscal years. During this 12-year period 308 explosions caused 1,338 deaths, an average of 111.5 deaths and 25.7 explosions per year. Although the number of explosions in the past fiscal year decreased about 30 percent below the average for the 12-year period, the number of deaths during the year (206) was about 100 percent more than the average of the preceding 11 years (102.9). For the 12-year period Pennsylvania has the greatest total number of explosions (88) with 220 deaths and West Virginia with 56 explosions the greatest number of deaths (248). Ohio with only 11 explosions had the next largest number of deaths (170). It is encouraging to note that during the 12-year period Kansas and Maryland are reported to have had only one explosion each, with a total of 3 deaths (2 in Kansas and 1 in Maryland); Tennessee, 4 explosions with but 1 fatality; and Alaska 1 explosion. Kansas is not known to have had an explosion during the past 11 years, and Utah is not known to have had one for the past 10 years.

The average number of deaths per explosion during the past 12 years has been 4.34, with a range for the various States from 0.2 in Tennessee to 15.45 in Ohio. States with the highest averages are Ohio, 15.45; Alaska, 14; Oklahoma, 9.80; and Virginia, 8.60. It is noteworthy that in these States relatively little attention has been given to the use of closed lights, permissible explosives, rock dusting, and precautions with electrical equipment. The following coal-producing States are not listed in table 3, as they are not known to have had an explosion during the past 12 years: Iowa, Michigan, Missouri, Montana, North Dakota, and Texas.

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TABLE 3. - Record of explosions, by States, during fiscal years 1929-40 1/

State	1929		1930		1931		1932		1933		1934		1935		1936	
	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions
Alabama	13	7	8	4	1	2	4	5	1	1	2	2	1	1	1	1
Alaska	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arkansas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
California	-	1	7	2	12	1	-	1	1	1	-	-	-	-	-	-
Colorado	-	-	1	1	-	-	-	3	1	1	-	-	-	-	12	2
Illinois	-	3	10	2	2	1	3	3	5	1	-	-	-	-	-	-
Indiana	-	-	-	-	28	1	-	-	4	2	-	-	-	-	2	3
Kansas	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kentucky	11	3	16	1	-	-	3	1	26	2	-	1	1	1	9	1
Maryland	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
New Mexico	-	-	-	-	8	3	-	-	14	1	-	-	-	-	-	-
Ohio	3	3	1	2	88	3	-	-	-	-	-	-	-	-	4	1
Oklahoma	1	1	71	4	45	2	-	-	3	2	-	-	3	2	-	-
Pennsylvania	70	9	16	8	23	7	7	6	9	6	16	14	24	11	8	10
Tennessee	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
Utah	1	2	30	3	-	-	-	-	-	-	-	-	-	-	-	-
Virginia	2	1	-	-	-	-	54	3	-	-	2	3	18	2	-	-
Washington	-	-	17	2	-	-	-	-	2	1	-	-	-	-	4	1
W. Virginia	36	7	23	5	11	4	11	7	9	5	8	4	5	4	3	3
Wyoming	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	-
Total	139	38	199	34	217	26	87	33	122	22	28	26	54	22	38	25

State	1937		1938		1939		1940		Total 12 years		Average per year		Average deaths per ignition
	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	
Alabama	-	-	37	2	-	1	1	4	65	29	5.4	2.3	2.42
Alaska	-	-	14	1	-	-	-	-	14	1	1.2	.08	14.00
Arkansas	5	1	4	4	-	-	3	1	12	6	1.0	.5	2.00
California	-	-	-	-	-	-	-	-	19	6	1.6	.5	3.17
Colorado	1	1	-	-	-	-	1	1	19	9	1.6	.7	2.11
Illinois	-	-	22	2	-	-	1	1	76	14	6.2	1.2	5.43
Indiana	-	-	-	-	-	-	-	-	56	8	4.7	.7	7.00
Kansas	-	-	-	-	-	-	-	-	2	1	.2	.08	2.00
Kentucky	-	-	2	1	-	-	28	1	79	13	6.1	1.2	6.08
Maryland	-	-	-	-	-	-	-	-	1	1	.08	.08	1.00
New Mexico	-	-	-	-	-	-	-	-	22	4	1.9	.3	5.50
Ohio	-	-	2	1	-	-	72	1	170	11	14.2	1.0	15.45
Oklahoma	3	1	-	-	-	-	2	1	129	14	10.8	1.2	9.14
Pennsylvania	14	5	30	7	-	-	1	2	220	88	18.3	7.3	2.50
Tennessee	-	1	-	-	-	-	1	1	1	5	.08	.4	.20
Utah	-	-	-	-	-	-	-	-	31	5	2.6	.4	6.30
Virginia	2	1	46	3	-	1	1	1	129	15	10.7	1.2	8.60
Washington	1	2	-	1	-	-	1	2	21	17	1.8	1.4	1.24
W. Virginia	36	8	53	3	6	4	95	2	248	56	20.7	4.7	4.41
Wyoming	-	-	5	1	-	-	-	-	8	2	.7	1.7	4.00
Total	62	20	170	29	16	14	206	18	1338	308	111.5	25.7	4.34

1/ The fiscal year ends June 30.

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CAUSES OF EXPLOSIONS

Table 4 gives data on causes of explosions in the United States during the past 12 years, as reported to the Safety Division of the Bureau of Mines by its field representatives. In all, 308 explosions have been studied during the 12-year period, an average of 25.7 explosions per year. There were 18 explosions during the past fiscal year, or 4 more than during the previous year and 8.4 less than the average for the preceding 11 years.

Table 4 shows that electricity was responsible for 125 (40.6 percent) and open lights and smoking for 112 (36.4) of the explosions listed; hence, 77 percent of all known explosions during this 12-year period were started by ignitions due to electricity, open lights, and smoking.

The number of explosions of electrical origin during the past year (6) is nearly 50 percent less than the average for the preceding 11 years (10.8), whereas the number caused by open lights or smoking (5) is about 50 percent less than the average (9.7) from these causes for the preceding 11 years.

Table 4 shows that 5 explosions were caused by explosives during the past year compared with no such explosions in the previous year and an average of 3.8 for the preceding 11 years. The favorable reduction in explosions caused by explosives for the 11 years preceding the fiscal year 1940 was thought to be the result of increased use of permissible explosives, increase in safe practices in handling explosives, improved ventilation, and more intensive supervision. However, the record of the past year is by no means creditable, as 103 fatalities resulted from mine explosions started by explosives. Moreover, the fact that during the fiscal years 1938 and 1940 explosions caused by explosives resulted in 164 deaths (see table 5) indicates that some practices now in effect in connection with use of explosives in coal mining are exerting a decidedly harmful influence on safety in the coal-mining industry.

The two explosions listed under miscellaneous or unknown causes resulted from deliberate disregard of common-sense safety practices; a nonpermissible flame safety lamp taken apart in the presence of gas (by no means an unusual procedure) caused one explosion, and the use of a gasoline locomotive underground caused the other (use of gasoline engines underground should not be allowed if various kinds of hazards are to be avoided).

EXPLOSION FATALITIES, BY CAUSES

Table 5 compares explosion fatalities by causes and shows that during the past 12 years 1,338 fatalities resulted from explosions in coal mines in the United States, an average of 111.5 per year. The record of explosion fatalities during the fiscal year 1940 is the worst since 1931. Three major explosions during the year resulted in 191 deaths and 15 minor explosions in 15 deaths; compared with the record for the fiscal year 1939, when no major explosions occurred and only 16 deaths resulted from minor explosions, the 1940 record is extremely unfavorable.

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TABLE 4. - Comparison of explosions by ignition causes, fiscal years 1929-40, inclusive

Year	Ignition by electricity		Ignition by open lights or smoking		Ignition by explosives		Ignition due to unknown or miscellaneous causes		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1929.....	18	47.4	11	29.0	8	21.0	1	2.6	38	100
1930.....	18	52.9	8	23.5	6	17.6	2	6.0	34	100
1931.....	9	34.6	11	42.3	6	23.1	-	-	26	100
1932.....	10	30.3	15	45.5	5	15.1	3	9.1	33	100
1933.....	8	36.4	8	36.4	4	18.1	2	9.1	22	100
1934.....	10	38.5	9	34.6	3	11.5	4	15.4	26	100
1935.....	10	43.5	9	39.1	2	8.7	2	8.7	23	100
1936.....	5	20.0	17	68.0	1	4.0	2	8.0	25	100
1937.....	12	60.0	5	25.0	1	5.0	2	10.0	20	100
1938.....	10	34.5	11	37.9	6	20.7	2	6.9	29	100
1939.....	9	64.3	3	21.4	-	-	2	14.3	14	100
1940.....	6	33.3	5	27.8	5	27.8	2	11.1	18	100
Total	125	40.6	112	36.4	47	15.2	24	7.8	308	100
Average	10.4	40.6	9.3	36.4	4.0	15.2	2.0	7.8	25.7	100

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TABLE 5. - Comparison of explosion fatalities by ignition causes, fiscal years 1929-40, inclusive

Year	Electricity		Open lights or smoking		Explosives		Unknown or miscellaneous causes		Total	
	Number killed	Percent	Number killed	Percent	Number killed	Percent	Number killed	Percent	Number killed	Percent
1929.....	93	66.9	14	10.1	26	18.7	6	4.3	139	100
1930.....	154	77.4	21	10.5	24	12.1	-	-	199	100
1931.....	143	65.9	56	25.8	18	8.3	-	-	217	100
1932.....	11	12.7	33	37.9	42	48.3	1	1.1	87	100
1933.....	25	20.5	63	51.6	29	23.8	5	4.1	122	100
1934.....	21	75.0	2	7.1	2	7.1	3	10.8	28	100
1935.....	29	53.7	6	11.1	3	5.6	16	29.6	54	100
1936.....	20	52.6	10	26.4	4	10.6	4	10.5	38	100
1937.....	53	85.5	3	4.8	-	-	6	9.7	62	100
1938.....	24	14.1	77	45.3	61	35.9	8	4.7	170	100
1939.....	13	81.3	2	12.5	-	-	1	6.2	16	100
1940.....	99	48.3	2	1.0	103	49.7	2	1.0	206	100
Total..	685	51.2	289	21.6	312	23.3	52	3.9	1,338	100
Average	57.2	51.2	24.1	21.6	26.0	23.3	4.3	3.9	111.5	100

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Explosions of electrical origin were responsible for 99, or 48.3 percent, of the deaths from explosions during the past fiscal year; this figure represents a marked increase over the 13 deaths from this cause during the previous year and the average of 53.3 for the preceding 11 years. One of the explosions classed as electrical killed 91 men; although the cause of this explosion was not definitely established, evidence indicated that electricity was the most probable source of ignition. In view of the rapid increase in the use of underground electrical equipment, much of which is operated from trailing cables and placed at the face regions where the hazard is maximum the record for several years before 1940 was distinctly favorable; however, virtually all of these explosions probably could have been avoided if readily available and efficient permissible equipment had been installed, kept in reasonable repair, and used with good judgment. With the rapid extension of mechanized mining, chiefly by electrically operated equipment, the least that should be done in the cause of safety is to use only the safest available types, and this means permissible equipment. An operator who installs permissible electrical equipment in his mine, then permits it to become nonpermissible and even highly hazardous through carelessness on the part of the mechanical and operating forces, is slack in the type of supervision he gives the property.

Open lights and smoking resulted in two deaths or about 1.0 percent of the fatalities due to explosions during the past fiscal year. This number is the same as that for the previous year but is a substantial decrease compared to the average of 26 deaths from open lights and smoking during the preceding 11 years. Carbide lamps were responsible for two explosions during the year; smoking for two; and a match used in an attempt to relight an ordinary lantern in a small wagon mine for one.

During the past 12 years 312 deaths (23.3 percent of all deaths due to explosions) resulted from the use of explosives. In the past fiscal year 103 deathsresulted from such explosions compared with no deaths from this cause for the previous year and an average of 19 for the preceding 11 years. One explosion, which caused the death of 72 men, is believed to have resulted from an overcharged shot of black blasting powder in pellet form; another, which caused the death of 28 men, resulted from ignition of dust by the premature explosion of a quantity of unconfined permissible explosives; another, in which 3 men were killed, resulted from the unsafe practice of shooting coal with dynamite off the solid using 6- to 8-foot holes loaded with 6 to 7 sticks of 60-percent dynamite in a 32-inch bed of coal; another, in which 4 men were injured, resulted from a blown-out shot of black powder; and still another, in which 2 men were injured, was caused by blasting out timber with permissible explosive.

In all of these explosions one or more of the well-established principles of safety in connection with coal-mine blasting were violated, and in at least two mines virtually all of the known hazardous coal-mine blasting practices were in effect. Undoubtedly the relative immunity to disasters caused by blasting in recent years has resulted in abandonment of safe blasting

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procedure, and it now appears that much laxity in blasting is accompanying the relatively rapid extension of mechanization in the coal mines of the United States.

ELECTRICAL CAUSES OF EXPLOSIONS

Table 6 gives data available to the Bureau of Mines on causes of explosions of electrical origin in the United States for the past 12 years. During this period there were 125 explosions of electrical origin, of which 6 with 99 deaths occurred during the past fiscal year.

Trolley or cable-reel locomotives and nonpermissible mining machines jointly were responsible for at least one-half of the explosions of electrical origin in the coal mines of the United States during the 12-year period and for one-third of the explosions of electrical origin that occurred during the past year in coal mines of the country.

In one explosion during the past year classed as electrical, which resulted in the death of 91 men, the cause was not definitely determined, but the preponderance of evidence as determined by Bureau of Mines investigators indicated that the explosion was caused by an electric arc. Nonpermissible mining machines were responsible for two explosions during the year, nonpermissible coal drills for two, and an arc from the switch of a conveyor motor for one.

Most coal-mine explosions of electrical origin during the past 12 years have shown evidence of carelessness or flagrant disregard of safe ventilation practices, such as doors left open (generally latched open) on main or important haulage entries; line brattices in poor condition or not extended close enough to the face; the coursing of air through or past partly caved, more or less inaccessible, and hence poorly ventilated workings; or other manifestations of neglect to control the coursing of air currents through mine openings and past mine workings. Other factors in these electrical ignitions of gas or dust were: (1) Failure to test for gas before going into working place with electrical equipment, such as mining machine, trolley locomotive, loading machine, or electric drill, or failure to test from time to time while using the equipment; (2) use of electrical equipment too soon after the mine fan has been started after a shut-down; (3) failure to examine a mine properly on idle days when only a skeleton crew is in the mine; (4) use of haulageways for return airways, a practice that has always been hazardous in the extreme, whether in gassy or so-called nongassy mines; (5) failure to install and utilize permissible electrical equipment or to maintain permissible equipment in a permissible or safe condition; and numerous other heedless or careless practices in connection with coal-mine procedures directly or indirectly involving ventilation.

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TABLE 6. - Electrical causes of explosions, fiscal years 1929-40, inclusive

Cause	Number of explosions of electrical origin by fiscal years												Total, 12 years	Number killed	
	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940		1939	1940
Trolley or cable-reel locomotive 1/.....	5	5	1	1	4	5	3	1	5	4	3	-	36	7	-
Nonpermissible mining machine 2/.....	5	5	3	3	1	-	2	1	3	3	-	2	27	-	6
Nonpermissible electrical motor.....	4	3	-	-	-	-	2	-	-	1	2	-	12	4	-
Nonpermissible shot-firing battery or circuit.....	-	3/ 2	3/ 3	1	-	1	-	-	-	-	-	-	2	-	-
Cable nips or blow-out...	-	2	-	-	-	1	-	-	1	-	1	-	5	-	-
Nonpermissible electric drill.....	-	-	-	2	-	1	2	-	-	-	2	2	9	-	1
Nonpermissible storage-battery locomotive.....	1	1	2	-	-	-	-	-	-	-	-	-	4	-	-
Nonpermissible electric hoist.....	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-
Faulty wiring.....	2	2	-	-	-	-	-	1	1	-	-	-	6	-	-
Trolley wire.....	1	-	2	1	-	-	-	1	-	-	-	-	5	-	-
Electric arc.....	2	-	1	2	1	2	1	4/ 1	1	2	1	2	16	2	92
Signal wire.....	-	-	-	-	1	-	-	-	1	-	-	-	2	-	-
Total.....	18	18	9	10	8	10	10	5	12	10	9	6	125	13	99

1/ 1 not included in total; may have been from open light.
2/ 1 not included in total; may have been from smoking.
3/ Not included in total; may have been from overcharged shot.
4/ Included, but may have been from smoking.

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COMPARISON OF LIGHTING IN MINES WHERE EXPLOSIONS OCCURRED

Table 7 shows the method of lighting in mines where explosions occurred during the past 12 years. Of the 308 explosions that occurred during this period, 112 (36.3 percent) were in open-light mines; 177 (57.5 percent) in closed-light mines; and 19 (6.2 percent) in mines in which the lighting practice was unknown. During the past fiscal year 6 (33.3 percent) of the explosions occurred in open-light mines compared to an average of 9.6 explosions per year in open-light mines during the preceding 11 years.

The fact that during the past fiscal year 61.1 percent of the explosions occurred in closed-light mines and that during the past 12 years 57.5 percent of all explosions occurred in mines using closed lights may be interpreted in several ways. Probably the most nearly correct explanation is that in many States the most gassy, hence the most dangerous, mines now use closed lights. No explosion is known ever to have been caused by an electric cap lamp; this indicates that probably there has been carelessness in other explosion-prevention practices, certainly in at least some closed-light mines, otherwise more than half of the coal-mine explosions in recent years would not have occurred in closed-light mines. In many mines where closed lights are adopted, undue dependence is placed on the lamps, with more or less open neglect of ventilation and other precautionary measures. Among the bad practices is the use of open types of electrical equipment (pumps, drills, cutting machines, loading machines, etc.); this shows a flagrant violation of sane mining and is absolutely indefensible. The use of the up-to-date permissible electric cap lamp is unquestionably one of the most effective means now known for promoting safety in mining (coal or metal), and any agency that fails to use or tries to prevent the use of electric cap lamps in underground mines is woefully ignorant of mine safety requirements or deliberately callous to the humanitarian operation of mines. Any organization that neglects other essential safety procedures through undue reliance on electric cap lamps is far too cold-blooded and callous to the requirements for conserving human life and limb to be allowed any connection with mines and mining.

EXPLOSIONS IN BITUMINOUS-COAL MINES

Figure 1 shows the trend of fatalities resulting from gas and dust explosions in bituminous-coal mines of the United States during the calendar years 1906 to 1939, inclusive. The trend of explosion fatalities was downward from 1907 to 1921, with a marked rise from 1922 to 1924 and a definite, fairly steady, decline from 1924 to 1935; however, the trend has been upward during the past 4 years, especially 1937 and 1938. It is significant that every alternate year from 1924 to 1936 the number of deaths has increased over the preceding year, although the general trend has been downward. A plausible explanation is that a year with a relatively low explosion-fatality record results in relaxation of accident-prevention (or at least explosion-prevention) efforts during the following year and, conversely, a year with high explosion-fatality record results in additional precautionary measures being taken. The tabulation on the graph of average annual fatalities from bituminous-coal-mine explosions for 5-year periods from 1906-10 to 1931-35 is illuminating, as it shows large and fairly steady decrease in annual fatalities from 436

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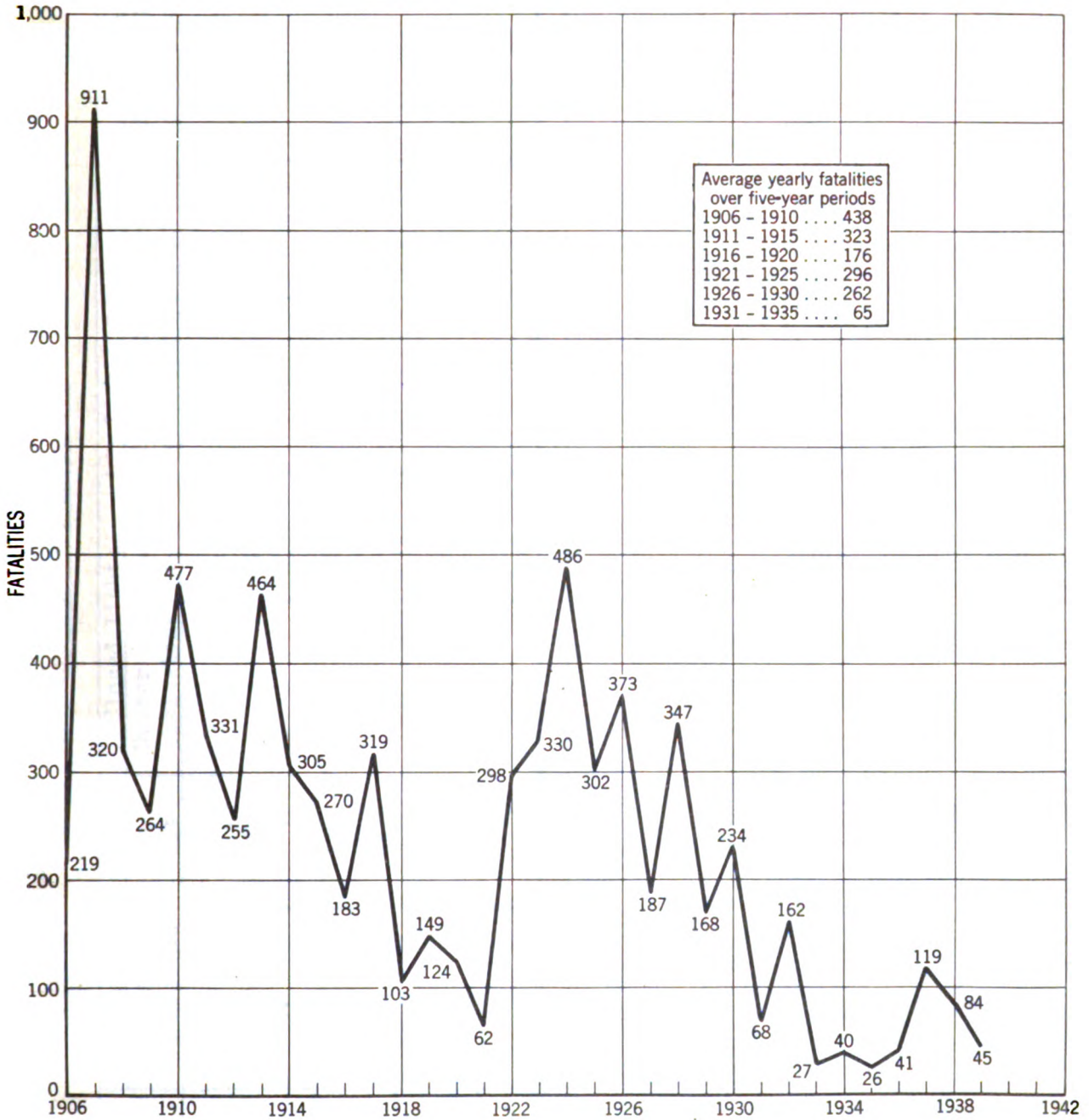

Figure 1.—Fatalities from gas and coal-dust explosions in bituminous-coal mines.

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TABLE 7. - Comparison of lighting in mines where explosions occurred, fiscal years 1929-40, inclusive

Year	Open lights		Closed lights		Lighting unknown		Total	
	Number of explosions	Per-cent	Number of explosions	Per-cent	Number of explosions	Per-cent	Number of explosions	Per-cent
1929.....	18	47.4	19	50.0	1	2.6	38	100
1930.....	8	23.5	25	23.5	1	3.0	34	100
1931.....	12	46.2	14	53.8	-	-	26	100
1932.....	15	45.5	14	42.4	4	12.1	33	100
1933.....	7	31.8	14	63.6	1	4.6	22	100
1934.....	9	34.6	14	53.7	3	11.5	26	100
1935.....	6	26.1	17	73.9	-	-	23	100
1936.....	15	60.0	9	36.0	1	4.0	25	100
1937.....	4	20.0	12	60.0	4	20.0	20	100
1938.....	10	34.5	16	55.2	3	10.3	29	100
1939.....	2	14.3	12	85.7	-	-	14	100
1940.....	6	33.3	11	61.1	1	5.6	18	100
Total	112	36.3	177	57.5	19	6.2	308	100

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for the 5-year period 1906-10 to 65 for the 5-year period 1931-35, a drop of 85.5 percent. The significance of this drop is seen from the fact that if the rate of explosion fatalities for the 5-year period 1906-10 (438 per year) had continued through 1935, 13,140 lives would have been lost from this cause instead of 7,800 (the approximate number actually lost). If the fatality rate for such accidents during the 5-year period 1931-35 (65 per year) had been in effect from 1906 to the end of 1935, the total would have been only 1,950 instead of 7,800 (the approximate number actually killed). It is significant also that during the past 5 years, 1935-39, fatalities from all coal-mine explosions in the United States averaged only 63 per year; if this average is compared with that of 438 fatalities annually for the 5-year period, 1906-10, inclusive, the reduction is 85.6 percent. In other words, for every 100 persons killed by coal-mine explosions during the period 1906-10 only 14.4 have been killed by them during the past 5 years. The production of coal in 1906-10 was about 451,000,000 tons per year, and in 1934-39 it was about 449,000,000 tons per year. These figures give a striking picture of the progress that has been made in the reduction of coal-mine explosion fatalities in the United States since the Bureau of Mines was commissioned by Congress in 1910 to reduce the annual death toll from that cause. No sane, fair-minded person can fail to admit that coal-mining people have done a good job in explosion prevention. The utmost effort should be made, however, to maintain the good record and not permit any recession such as appears to have begun in 1937 and 1938 and to have become distressingly bad during the first 7 months of 1940, when 3 major disasters occurred with a total of 226 fatalities - considerably more than the total number (179) of fatalities resulting from all kinds of coal-mine explosions (major and minor) for 1933-37, inclusive.

MINE FIRES

Because of the highly combustible nature of coal, timber, explosives, and other materials usually found in mines, the potential hazard of a fire is always present in every mine, whether coal or metal, even when the mine is classed as damp or wet. Some coals, ores, and other materials found or used in mines ignite spontaneously under certain conditions, creating a serious hazard where the coals or ores are being mined or the materials used; however, the most prolific ignition agencies in mine fires are electricity, explosives, and open lights. Despite ever-present fire hazards the mines of the United States have been fortunate during the past decade in that they have not experienced a fire that caused large loss of life; however, a number of fires have involved considerable property damage. Although much can be done to prevent mine fires, some companies still employ methods or equipment that have caused and probably will continue to cause fires in their mines. These include the use of black powder and fuse; slipshod methods of installing, using, and maintaining electrical equipment; use of open lights; smoking; and employment of other loose, unsafe, or out-of-date mining apparatus, methods, and practices.

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During the past fiscal year 27 fires, which resulted in the death of 2 men, were called to the attention of the Bureau of Mines. Scores of other fires were detected and extinguished promptly without much damage or were handled quietly and not reported to the Bureau of Mines, the general public, or even to State inspection forces.

Table 8 shows that during the past fiscal year 6 fires were reported by Bureau of Mines personnel in Pennsylvania and 6 in Colorado; 3 each in California and Kentucky; 2 each in Nevada and Virginia; and 1 each in Arkansas, Michigan, New Mexico, Tennessee, and Wyoming. Of the 27 fires, 1 was in an anthracite mine, 6 were in metal mines, and 5 were outcrop fires; the others were in bituminous-coal mines. Two fatalities resulted from the 27 fires; the two men killed were asphyxiated by gases from a fire in a Kentucky mine. Electricity caused 5 fires, open lights 2, and explosives 1; 19 fires were listed under "unknown or miscellaneous" causes, of which 2 probably were caused by spontaneous combustion, 2 by forest fires, and 2 by blow torches; 13 were of unknown origin. The 27 fires reported to the Bureau of Mines during the fiscal year 1940 were 3 more than the average for the preceding 10 years, and the 2 deaths resulting from fires during the past year were about 73 percent less than the average (7.4) for the 10-year period.

SUMMARY

It is interesting to note that of the 25 major coal-mine-fire disasters, with a total of 566 fatalities since 1900, only 4 (with 29 deaths) have occurred since 1921; that no major coal-mine fires occurred in the United States from 1926 to 1933, inclusive; and that 1 occurred in March 1934 with 5 fatalities, 1 in May 1935 with 6 fatalities, and 1 in August 1936 with 9 fatalities. The fact that 3 major mine-fire disasters occurred during 1934, 1935, and 1936, with a total of 20 deaths, compared with none in the preceding 8 years, indicates that proper precautions have not been taken in late years to prevent or handle mine fires. In a study of the circumstances connected with these fires the most striking feature brought out is the fact that improper procedure has been used in protecting workers who are attempting to fight the fires, or those engaged in rescue work, from poisonous or asphyxiating gases. Evidently mining people, through long immunity from harm to employees by mine fires, either have become negligent or have forgotten much about the hazards of mine fires and about safe and efficient practices and methods of preventing fires and handling them when they occur. Probably past lessons learned through the medium of fires with heavy loss of life some years ago have been forgotten; undoubtedly many operating men of today, not having had the lesson of tragic experience, really need education as to necessary precautions in the safe methods of handling as well as preventing fires. The action of mine officials during several fires of the past few years clearly indicates a lack of knowledge as to procedure in controlling such fires and an apparent indifference to hazards resulting from these fires.

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TABLE 8. - Summary of mine fires, by States, fiscal year 1940 and 1930 to 1939, inclusive

State	Lighting used			Fatalities by ignition cause									
				Electricity		Open lights		Explosives		Unknown or miscellaneous		Total	
	Open	Closed	Unknown	Deaths	Fires	Deaths	Fires	Deaths	Fires	Deaths	Fires	Deaths	Fires
Arkansas.....	1	-	-	-	-	-	-	-	1	-	-	-	1
California...	2	1	-	-	1	-	-	-	-	-	2	-	3
Colorado.....	3	1	2	-	1	-	1	-	-	-	4	-	6
Kentucky.....	1	2	-	2	2	-	-	-	-	-	1	2	3
Michigan.....	-	-	1	-	-	-	-	-	-	-	1	-	1
Nevada.....	1	-	1	-	-	-	1	-	-	-	1	-	2
New Mexico...	1	-	-	-	-	-	-	-	-	-	1	-	1
Pennsylvania.	-	4	2	-	1	-	-	-	-	-	5	-	6
Tennessee....	1	-	-	-	-	-	-	-	-	-	1	-	1
Virginia.....	1	1	-	-	-	-	-	-	-	-	2	-	2
Wyoming.....	1	-	-	-	-	-	-	-	-	-	1	-	1
Total, 1940	12	9	6	2	5	-	2	-	1	-	19	2	1/ 27
1939.....	9	9	2	1	8	-	1	-	3	2	8	3	20
1938.....	7	6	13	1	7	2	2	-	1	5	14	8	24
1937.....	7	4	10	9	5	-	-	-	3	2	13	11	21
1936.....	16	4	3	1	7	-	2	-	3	3	11	4	23
1935.....	7	5	14	11	11	-	1	-	-	-	14	11	26
1934.....	10	5	3	-	4	-	-	5	5	1	9	6	18
1933.....	12	6	9	-	7	-	-	-	2	2	18	2	27
1932.....	8	5	8	1	8	-	-	-	3	-	10	1	21
1931.....	12	7	5	-	7	5	3	-	5	18	9	23	24
1930.....	7	8	9	2	9	3	6	-	3	-	6	5	24
Total, 11 years	107	68	82	28	77	10	17	5	29	28	133	76	2/ 255

1/ Includes 6 metal-mine fires and 5 outcrop fires.
2/ Includes 38 metal-mine fires and 11 outcrop fires.

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The decrease in frequency and severity of explosions in the United States during the past 30 years has been encouraging and indicates that efforts to prevent explosions have been largely successful. The record for the fiscal year 1939 was the best in the history of coal mining since it became a major industry; however, the record for the fiscal year 1940 is by no means favorable, as three major explosion disasters during the year were responsible for 191 deaths, virtually all of which were due to failure to take proper precautions to prevent the spread of the explosions. In spite of the rapid increase in use of electrical equipment during the past few years, which has added many possible sources of electrical ignition at face regions, explosions from electric arcs have decreased, indicating that more effective precautionary measures are being taken, including the more intensive supervision that can be given when mechanization is properly handled. Although electric-arc ignitions of gas or dust in coal mines have been reduced, explosions originating from blasting procedures in mechanized mines have increased in recent years to such an extent as to create a serious menace to safety in the operation of such mines.

Some of the salient points brought out by the Safety Division of the Bureau of Mines in the study of explosions and fires in the United States during the fiscal year ended June 30, 1940, are:

1. Eighteen explosions, all in bituminous-coal mines, were studied compared to 14 explosions in 1939 and an average of 26.4 explosions in the previous 11 years. The number of ignitions in recent years is much less than in the past. The average number of ignitions for 1929-33 was 30.6 per year, and the average for 1936-40 was 21.2, a reduction of nearly 30 percent.

2. Explosions took 206 lives in the fiscal year 1940 compared with 16 in 1939 and an average of 102 in the previous 11 years. The anthracite mines of the United States, which employ about 100,000 persons and produce between 40 and 50 million tons of coal (much of it from mines that are decidedly gassy and difficult to ventilate), have operated more than 2 years without a major explosion disaster; this is a record of which the anthracite industry may be proud. The increase from 16 killed by explosions in the fiscal year 1939 to 206 in the past fiscal year (1940) certainly reflects no credit on those engaged in the forwarding of safety in the coal-mining industry; it is decidedly significant that fatalities in coal mines from causes other than explosions are decreasing as fatalities from explosions pile up, indicating that something is very wrong in explosion-prevention procedure and practice. Most of the trouble seems to be in bituminous-coal mines, particularly those of Alabama, West Virginia, Virginia, Kentucky, Pennsylvania, and Ohio.

3. The three major explosions during the past fiscal year resulted in 191 deaths compared to no major explosions in 1939; all three were in highly mechanized mines, and in two of the three disasters the ignition was precipitated by blasting procedure. Had proper rock dusting to prevent propagation of explosions been in effect in these three mines, the death toll undoubtedly would have been greatly reduced and possibly one or more of the explosions would have been prevented.

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4. Six explosions occurred in open-light mines compared with 2 in 1939 and an average of 9.6 in the preceding 11 years; 11 were in closed-light mines compared to 12 in 1939 and an average of 15 during the preceding 11 years. In the fiscal year 1940, as in former years, some of the explosions in closed-light mines were caused by open flames (matches used by smokers and the misuse of flame safety lamps). The persistence of the near-criminal habit of smoking in closed-light mines is deplorable, indicating that many mine workers are callous not only as to their own safety but also as to the safety of their fellow workers. Mine officials are not always free of responsibility because they are often indifferent in the enforcement of no-smoking rules and careless in the search for smokers' articles. One of the major disasters of the past fiscal year is held by some investigators to have been caused by smoking in a very gassy mine; others assessed the ignition to an electric arc. The occurrence virtually every year of explosions (some with heavy loss of life) due to defective flame safety lamps or the misuse of flame safety lamps indicates that they should be used by relatively few people and that their use should be safeguarded by rigid restrictions. Only permissible types kept in permissible condition should be employed and then only by persons carefully instructed not only in the use but also in the limitations and hazards of the equipment.

5. Six explosions, causing 99 deaths, were of electrical origin compared with 9 such explosions and 13 deaths in the previous fiscal year and an average of 10.8 with 53 deaths annually for the preceding 11 years. As previously pointed out, the rapid introduction of electrical equipment at face regions in connection with mechanical mining has greatly increased the potential hazard of explosions of gas or dust from electrical sources, and unless great care is taken such explosions are almost certain to increase. The least that should be done in placing loading and other equipment at or near gassy and dusty faces is to make certain that effective ventilation is maintained and that only the safest available equipment is used, which means permissible electrical equipment maintained in a permissible condition. Inspection of many mines where permissible equipment is used has shown gross neglect of ventilation and equipment. In addition to being uneconomical, these practices are bound to result in disaster sooner or later.

6. Open lights and smoking caused 5 explosions and 2 deaths in 1940 compared to 3 explosions and 2 deaths in 1939 and an average of 9.7 explosions and 26 deaths annually during the preceding 11 years. The five explosions due to open lights and smoking in 1940 were in bituminous-coal mines; in previous years anthracite mines have suffered heavily from gas ignitions caused by open lights and smoking. Two of the five ignitions were caused by carbide lights, two by smoking, and one by a lighted match in attempting to relight a lantern.

7. Four explosions and 103 deaths were caused by explosives during the fiscal year 1940, compared with no explosions from this cause in 1939 and an average of 3.8 explosions and 19 deaths annually in the preceding 11 years. The use of dynamite or black blasting powder either in pellet or granular form in coal mines is a definite violation of established safe mining

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practice and will continue to take lives until prohibited by law. Carelessness in methods or practices of using permissible explosives also is almost certain to result in disaster, as permissible explosives lack much of being foolproof; in fact, in the past 3 calendar years (1937-39) three major bituminous-coal-mine explosions with a total of 107 fatalities were initiated by blasting procedure in highly mechanized mines, the explosive in use (or misuse) in all three mines being of the permissible type.

8. Although rock dust was used to some extent in at least six mines in which explosions occurred during the past fiscal year, in most of these mines its use was perfunctory. The folly of partly rock dusting a mine was well-demonstrated in at least two mines during the year, and it was definitely established that rock dusting main haulageways and neglecting the back entries will not stop propagation of an explosion unless the original ignition occurs in a well-rock-dusted part of the haulage entry. Adequate rock dusting requires that all accessible surfaces in a mine be kept covered with a coating of rock dust unless those surfaces are wet. This requirement is by no means impossible and, if fulfilled, will almost certainly eliminate widespread explosion disasters; in most mines it can be done at an expense little, if any, greater than 1 cent per ton of coal produced. At present probably not more than 1 or 2 percent (certainly not as many as 5 percent) of the coal mines of the United States are kept adequately rock-dusted.

9. Of the explosions that occurred during the past fiscal year, 15 are thought to have been initiated by gas and 4 by coal dust. In almost all the explosions initiated by gas it was indicated that the ventilating current had been interrupted, and in some of the mines inspection for gas had been anything but adequate. It is evident that ventilation practice is not as efficient in many mines of the country as it should or could be. Very often ventilation is neglected, and undue reliance is placed on electric cap lamps, permissible explosives, rock dusting, and other installations and practices that require less continuous personal attention and effort by operating officials. In too many mines it has been found that operating officials are ignorant of proper ventilating requirements and do not realize or show proper respect for the hazard of gas.

Several of the ignitions were in so-called nongassy mines "never before known to give off gas" or known to give off a "little" gas or emit gas "occasionally." The real fact is that all mines should be considered potentially gassy.

One of the features of the gas ignitions was the fact that the blower fan-canvas tubing combination was a factor in at least 5 of the 15 explosions in which gas was ignited, usually in highly mechanized mines.

10. The frequency of explosions during the past year showed a marked decrease compared to the average for the preceding 11 years; however, the severity of the explosions was much higher than average. The average number of deaths per explosion last year was 11.4 compared to an average of 1.14 in 1939 and of 3.90 during the preceding 11 years. The average of 11.4

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deaths per explosion is considerably higher than that in any of the past 12 years; the next highest average (8.3) was in 1931. This heavy increase in the severity of coal-mine explosions is a decidedly unsatisfactory trend, and coal-mining people should take adequate action to counteract this very disturbing feature of present-day operation. No fatalities resulted from six of the explosions.

11. The 206 deaths caused by explosions during the past fiscal year (the greatest number in any fiscal year since 1931 when 217 were killed) occurred in 12 States; 14 of the coal-producing States had no fatalities from explosions so far as is known.

12. During the fiscal year 1940, 27 fires (including 6 in metal mines) with 2 deaths were reported compared with 20 fires and 3 deaths in 1939 and an average of 22.8 fires and 7.4 deaths for the past 10 years.

13. Of the fires during the year, 5 were of electrical origin, 2 were caused by carbide lamps, 1 was caused by explosives, 2 were of spontaneous origin, and 17 were of miscellaneous or unknown origin.

14. The frequency of mine fires has shown no appreciable reduction during the past decade; this should serve as a warning to mining people, because even though fatalities caused thereby have decreased in recent years their occurrence usually causes heavy property damage and almost invariably requires considerable ultrahazardous effort in extinguishing the fire or trying to control it. The potential hazard of fires in any mine is always serious, especially in coal mines, because they may precipitate explosions. Every underground mine has fire hazards, even those that are largely wet or that contain relatively little combustible matter; this should be recognized and plans made and kept in operation to handle fires quickly and safely if and when they occur.

15. The undesirability of using haulageways as return airways was demonstrated following at least two explosions during the year; this has been evident for many years and in metal as well as in coal mines. In both explosions lives were lost and unnecessary delay was experienced in recovery work because the main haulageways were on return air. Undoubtedly some advantages in operating efficiency result from holding main haulage roads in return air, but the practice has numerous safety hazards not only at time of mine fire or explosion but also during operating periods. If the advantages are such as to warrant the safety risks (which are heavy), at least readily available, easy-to-travel escapeways should be maintained in intake air for use of underground workers in leaving the mine hurriedly in case of fire or explosion.

CONCLUSIONS

This circular was compiled in essentially the same manner as were those of previous years (see Information Circulars 6178, 6419, 6540, 6680, 6761, 6819, 6870, 6927, 6986, 7048, and 7092) and embodies only facts revealed through studies by field employees of the Safety Division of the Bureau of

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Mines. The Bureau of Mines attempts to obtain information concerning every explosion and most fires in mines of the United States, but some of the less destructive may not have been brought to its attention early enough to permit investigation. However, the Bureau rarely fails to obtain fairly complete details of mine explosions in which more than one life is lost or in which considerable property is damaged; therefore, the data in these publications are relatively complete, especially as to mine explosions causing loss of more than one life.

The available information on mine fires is not as complete as that on explosions, and scores of fires undoubtedly occur every year in coal and metal mines without the knowledge of the Bureau of Mines or even the State inspection forces. Mine fires occur almost daily in some coal mines, particularly at shot-firing time where black blasting powder or dynamite is used or where the coal fires spontaneously; moreover, fires of electrical origin and those caused by open lights are by no means uncommon in metal mines.

Although metal-mine fires with heavy loss of life, such as the North Butte (Mont.) fire in 1917 with 163 deaths or the Argonaut fire in California in 1923 with 47 fatalities, have been absent from the mine-safety picture for many years, fires still occur in or around metal mines. Recently an oil heater exploded in a metal-mine change house and caused a fire that completely destroyed the house and numerous adjacent structures and for a time menaced the mine; another metal-mine change house was consumed by fire caused by an oil heater, and an underground electric-hoist installation started a fire with resultant heavy damage and cost.

Fortunately no lives were lost in these fires, but they serve to remind metal-mining people that fire hazards continue to exist in and around metal mines. Probably it would be well to take an occasional inventory as to possible fire hazards and then make certain that these hazards are removed or at least safeguarded so that they cannot become menaces.

A study of data available on mine explosions in the United States during the past 12 years reveals an encouraging reduction in the frequency and severity of these disasters until 1940. Although the record for 1940 was one of the worst in the 12-year period, the record for 1939, in which no major explosion disaster occurred, was the best in the history of coal mining in the United States for at least 60 years.

The fact that three major explosions with a total of 191 deaths occurred during the past year indicates lack of proper efforts to prevent widespread explosions. All three major explosions in the past fiscal year occurred in highly mechanized mines, and two were in so-called "modern" mines. In two of the disasters explosives are believed to have been the initiating cause with dust as the material ignited, although in one explosion gas may have had some part; in the third, electricity is believed to have caused the ignition and explosive gas to have been the material ignited. In all three mines numerous unsafe practices were in evidence; some evidently were

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caused by procedures thought necessary to make maximum use of mechanical loading and other equipment and produce maximum tonnage (probably at minimum cost).

Since 1932 coal mines in the United States have shown a reasonable tendency to decrease accident occurrence, but much of the progress has been in curbing fatalities from mine disasters; in this period mechanized-loading bituminous-coal mines have been the scene of mine disasters aggregating more than 300 fatalities, whereas disaster fatalities in non-mechanized-loading bituminous-coal mines have aggregated slightly over 100. In other words, highly mechanized bituminous-coal mines, which produced not more than one-third of the country's bituminous coal, had about three-fourths of the fatalities from major disasters.

The trend in the calendar years 1938 and 1939 and in 1940 (to July 1) has been excessively bad as regards fatalities from major disasters in highly mechanized bituminous-coal mines; of 9 major disasters in the coal mines of the United States during 1938, 1939, and the first half of 1940 with 274 persons killed, 4 with 236 fatalities occurred in highly mechanized bituminous-coal mines, 3 with 20 killed in non-mechanized bituminous-coal mines, and 2 with 18 killed in anthracite mines. In other words, about 86 percent of the fatalities from major disasters in the coal mines of the United States (both bituminous and anthracite) in this period occurred in highly mechanized bituminous-coal mines. If the 2 major disasters in anthracite mines are excluded and bituminous-coal mines only are considered, it appears that in the past 2 1/2 years more than 91 percent of the fatalities from major disasters in the bituminous-coal mines of the United States have occurred in highly mechanized mines.

The explosions to which reference is made are the following: The Keen Mountain disaster of April 22, 1938, which occurred on an afternoon shift in a mechanical-loading mine and in which 45 persons were killed by a coal-dust explosion when some bulldozing shots of permissible explosives were fired to break roof rock that had fallen; the disaster of July 14, 1939, at the mechanical-loading Duvin mine in Kentucky, which occurred when a shot firer was making up some priming cartridges of permissible explosives and electric detonators and a premature detonation of the explosives caused a dust explosion, killing 28 persons; the Bartley (W. Va.) disaster in January 1940, which occurred in a very gassy, highly mechanized mine and which Bureau of Mines investigators believed was precipitated by ignition of explosive gas by an electric arc; and the explosion at Willow Grove, Ohio, in March 1940, which Bureau of Mines investigators concluded was caused when a shot firer put off a shot in an advancing entry face with pellet powder, using coal-dust stemming, and the shot, which apparently had too little burden, ignited dust (and possibly some explosive gas from shots fired just previously), the resultant explosion killing 72 persons (this mine was highly mechanized).

From these explosions it would appear that the rather general criticism of the coal-mining industry in connection with recent mine disasters has resulted chiefly, in fact almost wholly, from the failure of highly mechanized

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bituminous-coal mines to take the necessary precautions towards safeguarding mines and mine workers. The fact that 91 percent of the major-disaster fatalities in bituminous-coal mines of the United States during the past 2 1/2 years occurred in highly mechanized mines, which produced about one-third of the bituminous coal of the country, seems to indicate that the hand-loading mines (at least for the past several years) have been doing a fairly good job in reducing major mine disasters, whereas the highly mechanized mines are failing to do their share in absolving the good name of coal mining from criticism as to major mine disasters.

The mechanization of coal mines unquestionably introduces additional explosion and other hazards, although it affords numerous opportunities to decrease many types of hazards that accompany more primitive mining practices and methods. In addition to the mechanical hazards involved in mechanized mines, there is almost invariably a considerable concentration of workers readily susceptible to injury from any untoward occurrence; moreover, the more rapid extraction of coal as a result of mechanical loading liberates greater quantities of gas and dust in a given period than does hand loading, and the gas is liberated in the presence of an increased number of sources of ignition, chiefly in connection with electrically operated equipment. Consequently, better ventilation must be provided and greater vigilance maintained in the detection of gas and in the elimination or neutralization of dust. Many explosions result directly or indirectly from carelessness or infractions of rules by employees, and many of them result from unsafe methods, installations, or practices (or all three) for which the management is responsible; therefore, the prevention of explosions is the responsibility not only of the management but also the workers. Irrespective of responsibility, there is no question as to the seriousness of the situation brought about by the very bad coal-mine disasters of the past 3 years (including the Mulga disaster of October 1937), and all persons engaged in coal mining, especially those trying to reduce accident occurrence in the coal mines of the United States, are now confronted with the difficult problem of trying to bring disaster occurrence in coal mines of the country back to the exceptionally good record of the fiscal year 1939, when no major explosions occurred.

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